

DO WE ALREADY HAVE SAMPLES OF CERES? H CHONDRITE HALITES AND THE CERES-HEBE LINK.

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Summary: We investigate the hypothesis that halite grains in the brecciated H chondrites Zag and Monahans originate from Ceres. Evidence includes mineralogy of the halites consistent with formation on a large, carbonaceous, aqueously active body close to the H chondrite parent body >4 Ga ago. Evidence also includes orbital similarities between 1 Ceres and the purported H chondrite parent body (HPB) 6 Hebe, possibly facilitating a gentle transfer between the bodies.

Discussion: Halite grains in the Monahans and Zag H-chondrites are exogenous to the H chondrite parent body and were transported to the HPB >4 Ga ago. Examination of minerals and carbonaceous materials entrained within the halites shows that the halite parent body (HaPB) is consistent with a carbonaceous body [1]. It is probably a large body due to the variety of entrained carbonaceous materials which probably accreted from multiple sources. The halite grains contain intact, HaPB-origin, ancient fluid inclusions indicating that transfer between the HaPB and the HPB was a gentle process resulting in a ΔT of <25 °C. Ejection from the HaPB may have been via cryovolcanic processes similar to those on modern-day Enceladus, which have been interpreted to include halite from spectroscopic observations. The ΔT_{max} to preserve the brine-bearing halite restricts the impact velocity to the HPB at less than $\approx 350\text{--}700$ m/s, depending upon the fraction of kinetic energy used to heat the sample. [2-6]. Therefore the HaPB and HPB must have shared nearby orbits at the time of the HaPB-HPB transfer.

Evidence presented elsewhere indicates asteroid 6 Hebe is a favored candidate for the HPB based on reflectance spectrum similarity with H chondrites and dynamical arguments [7,8]. The modern orbits of Ceres and Hebe are reasonably similar, with aphelion/perihelion of Ceres and Hebe of 2.99/2.55 and 2.91/1.94 AU, respectively. Initial calculations indicate an approximate mean infall velocity of 1.20 to 1.38 km/s. While higher than 350-700 m/s, the orbits may have been more favorable >4 Ga ago. Additional dynamical factors need to be investigated.

A combination of factors suggests Ceres as the HaPB. It is a carbonaceous body with suggestions of past aqueous activity [9], which is consistent with the mineral species found in H chondrite halites. Ceres is also a large body capable of accreting the range of carbonaceous materials noted [5]. It is relatively near to purported HPB Hebe, which is required to preserve halite fluid inclusions. The above evidence defines a hypothesized scenario featuring ejection of halite grains from Ceres onto Hebe. Halite was then entrained in H-chondrite near-surface breccias and ejected from Hebe for transport to Earth.

References: [1] Zolensky *et al* This meeting. [2] Zolensky *et al* 1999 *Science* 285:1377-1379. [3] Rubin *et al* 2002 *MAPS* 37:125-142. [4] Fries, Steele, Zolensky 2012. Abstract #5381. 75th MetSoc Meeting. [5] Zolensky *et al* 2012. Abstract 6024. Life Detection in Extraterrestrial Samples Meeting. [6] Fries, Zolensky, Steele 2011. Abstract #5390. 74th MetSoc Meeting. [7] Bottke *et al* 2010. Abstract #40.06 DPS Meeting #42 Bull. Am. Ast. Soc. 42 p.1051. [8] Gaffey and Gilbert 1998. *MAPS* 33:1281-1295. [9] Rivkin *et al* *Icarus* 185 (2): 563-567.